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"THE NEXT **15 YEARS** ARE THE **MOST EXCITING** I'VE EVER SEEN IN MY CAREER"

— Mark Reynolds, Mace

CEOs join industry's biggest debate: an eight-page special from the CN Summit 2014

McLaren fashions Mayfa

Phased construction meant this building could go up quickly and with minimal disruption to neighbouring streets and businesses

Three-storey height slim column trusses maximise the useable floor area and speed up construction

PROJECT REPORT
RUBY KITCHING

With its hand-crafted tile-clad exterior and precision fabricated steel-framed structure, a new six-storey building in London's exclusive Mayfair district is à la mode for traditional and modern construction techniques.

Seeking to grab the catwalk limelight from its neighbouring flagship fashion boutiques is a new retail and office building on the corner of Savile Row and Conduit Street in London. Designed to reflect the quality of craftsmanship of this famous tailoring district, the exterior will be clad in 10,000 bespoke, locally crafted, black and white ceramic tiles with a crystalline glaze. The main structure is steel-framed with a concrete core to meet the needs of a tight construction programme and a city centre site with virtually no storage area.

Two existing buildings were demolished on the site in the summer of 2013 and the existing concrete basement extended to fill the entire footprint ahead of the six-storey building being constructed. Main contractor is McLaren Construction, steelwork contractor is BHC and structural engineer is Capita. Work on site is currently focussed on fitting out.

Project	Conduit Street/Savile Row
Main client	Aerium and Terrace Hill Group
Architect	EPR Architects
Main contractor	McLaren Construction
Structural engineer	Capita Symonds
Steelwork contractor	BHC

The new structure has been massed to reflect the original plot widths of the site and to ensure it echoes the same rhythm of building sizes on the street. Basement, ground and first floor levels will be for retail use and upper floors will be offices. The building steps back at level five, again to line up with neighbouring buildings and create a terrace for offices on this floor. The roof will house plant.

Neighbouring buildings had to be underpinned to allow the new development to take place, while abutting pavements had to be propped during construction.

450mm
Westok cellular beams

Cellular beams have ensured that floor depths are slim

Floor beams spanning up to 10m are all 450mm deep Westok cellular beams and accommodate services within their web openings. The advantage of this has been that the floor build-up comprising structural steel decking with 150mm thick insitu concrete is slim, maximizing the number of storeys which can be fitted into the allowable height for the building.

Perimeter vertical support is provided by three-storey tall trusses made up of 200mm by 150mm rectangular hollow section booms and 114mm diameter circular hollow section bracing. These arrived on site as complete members to reduce the number of connections which needed to be made on site and speed up erection. The trusses provide a slim "column" solution which also maximises the useable floor area.

The long-spanning beams have meant that, aside from the core and perimeter trusses, only a single internal column is required for vertical support at each level, keeping floor spaces as open as possible, says associate director Stephen Pey for architect EPR. "As with a Savile Row suit we agreed that the building should be formed of a simple cut while using the finest of craft materials".

With only a single lane of Savile Row available for deliveries and storage, one of the main reasons for choosing a steel-framed structure was because it allowed for phased construction. This is where half the site at any one time can be used as a laydown area, while the other half is being erected.

"It's a demanding project because of the [tight] time frame and logistics of managing traffic and site deliveries. Construction has been planned with precision to enable trades to work concurrently" comments McLaren Construction Senior Site Manager Andy Case.

A five-phase erection sequence devised by BHC and McLaren has allowed three storeys of the Savile Row elevation to be constructed first as part of phase one, using the ground floor on the Conduit Street elevation for lay-down. The structurally complete third floor on the Savile Row elevation was then used for lay-down while ground-third floor steelwork in phase two was erected for the Conduit Street elevation. Phase three involved building three storeys from the third floor of the Savile Row elevation while the Conduit Street structure was used for lay-down. This staggered sequence continued in phases until the final roof steelwork for phase five was erected.

ir build

"That was the only way you could build this structure [phased and in steel] when the building itself takes up the entire footprint of the site," comments Mr McCormick.

Since part of the building on Savile Row will have bay windows projecting out from the main building line, exterior scaffolding from which the cladding will be fixed has had to frame around these openings. The windows are permanently supported by an angle detail made up of box sections which are bolted to the perimeter floor beam. Across the exterior, a quick to construct Kingspan-insulated Metsec rainscreen cladding system will keep the building water tight to allow fit out to proceed and tiles to be fixed.

The project is targeting a BREEAM level of "Excellent" and is due to be complete early 2015.

PRECISION DELIVERIES

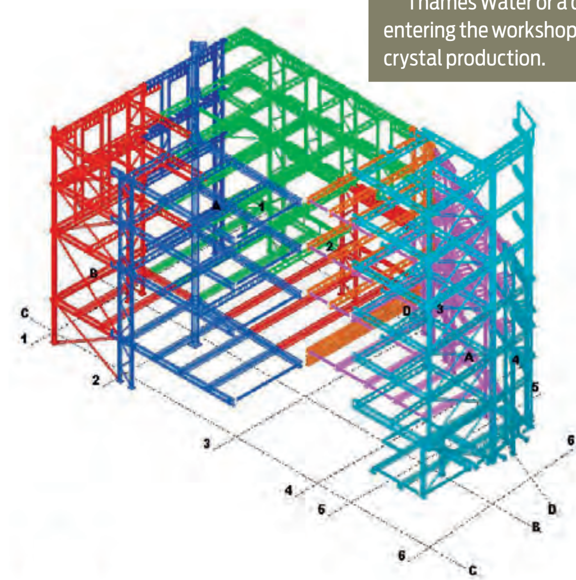
McLaren construction site manager Andy Case says that deliveries had to be optimised to ensure maximum use of each crane lift and for all components arriving on site to be scheduled for immediate use. Extra care has also been taken to ensure that all deliveries are planned in a way that ensures everything is used up, since there is no time to send away unused components and for them to be returned later. Mr Case continues, "We have brought everything to site as it is needed and incorporated off-site manufacture wherever possible."

The time invested in planning the construction of this building has undoubtedly saved time on site. BHC project manager Bobby McCormick adds that consideration had to be given to the order in which each steel member being delivered was to be used so that each trailer arrived with steelwork ready to be lifted in the correct sequence. BHC also erected the metal decking, and similarly had to ensure this was packaged up and delivered in sequence of erection.


Hand–glazed ceramic tiles will clad this retail and office building in Mayfair, London

TILES

The glaze to the tiles has been developed by ceramic artist Kate Malone and hand-glazed by Froyle Tiles. Each tile has a crystalline glaze which is different for every tile due to the temperamental way in which the crystals grow as the tile cools in the kiln. Even variations in sodium chloride content of water from Thames Water or a draft entering the workshop effects crystal production.


Phased construction meant this building could go up quickly and with minimal disruption to neighbouring streets and businesses

Steel industry leads the

Only a calculation that takes into account the whole life of a building or component of a building can provide an accurate measure of its embodied carbon impact, writes BCSA's John Dowling

LOW CARBON
JOHN DOWLING

The Government has set ambitious and legally binding targets to reduce national greenhouse gas emissions and as the operation of buildings currently accounts for nearly half of these a significant improvement in new and existing building performance is required if these targets are to be met. This is being achieved for new buildings by enhancing the standards set out in Approved Document L.
As efforts to reduce operational carbon in buildings through improved legislation and standards starts to have an effect the relative importance of embodied carbon is increasing.

But what is embodied carbon? The term embodied carbon, when applied to construction materials or products, refers to the lifecycle greenhouse gas emissions that occur during their manufacture. The definition can also include any emissions that occur during the construction process, the operational lifetime of the building and the end of life disposal of the materials used in the building.

This is sometimes referred to as the cradle to (factory) gate option, the cradle to (installation) site option, or the cradle to cradle option, the latter of which is also known often as the whole life approach.

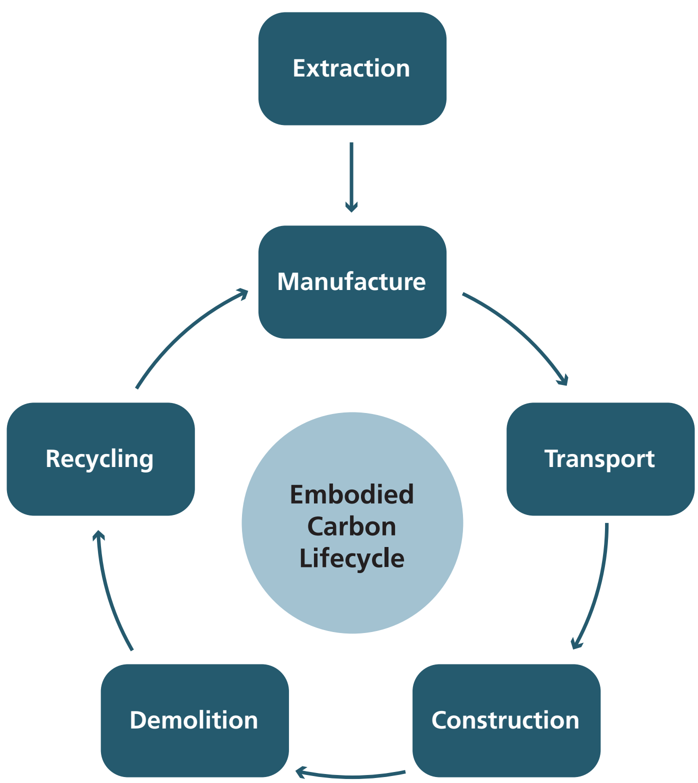
"The steel industry promotes the whole life approach to embodied carbon calculation," says John Dowling, British Constructional Steelwork Association Sustainability Manager. "Only this cradle to cradle method will give you an holistic understanding of the lifetime impacts of construction materials. The other methods fail to do this."

Mr. Dowling goes on to say: "The strength of a cradle to gate approach to embodied carbon calculation has in the past been that information has been readily available for most materials. The quality of that data may be questionable on occasion but its saving grace is that it has been there. The weaknesses however are significant because the cradle to gate approach assumes that all materials are more or less equal at end of life. So, recycling is deemed to be the same as landfill and a material that leaves a detrimental legacy when it comes to the end of its useful life is considered to be the same as one that leaves a positive impact.

> **"The steel industry promotes the whole life approach to embodied carbon calculation"**

The strength of a cradle to cradle approach is that it does not assume that all end of life outcomes are equal and that positive outcomes at end of life, such as recycling are rewarded and negative outcomes, such as landfill, are penalised. In the past, the weakness of this approach has been a lack of whole life data, but that has now been remedied. The steel, concrete and timber industries have all put their houses in order and produced good, reliable end of life data."

To help the construction industry navigate its way through the process of embodied carbon calculation, Tata Steel and the British Constructional



HELP FOR MULTI-STOREY DESIGNERS

A web tool that enables designers of multi-storey buildings to easily estimatethe embodied carbon footprint of the superstructure has been developed and is available for download at www.steelconstruction.info/Design_software_and_tools

Designers can use the tool in two ways. In'auto-generate' mode, the basic building geometry, structural grid and chosen floor system are used to estimate structural material quantities using algorithms developed by the Steel Construction Institute (SCI).

Alternatively, a user may use the 'manual input' mode to enter the actual material quantities for the building. To compare the impact of a steel framed building with a concrete framed building, the web tool should be run separately for each building.

way in carbon calculation

Steelwork Association have published a guide on the subject, the latest in their series of steel construction guidance publications.

A must read for the entire construction industry, the guide explains what embodied carbon is and how it impacts on the total emissions of a building throughout its lifecycle.

The guide gives designers an overview of how embodied carbon should be considered and calculated, some practical guidance on how to assess it on individual projects, and the significance of end of life impacts, while some case studies show how structural steelwork compares with other framing materials.

The guide is available for download at www.steelconstruction.info/Steel_construction_news

EMBODIED CARBON DATASET

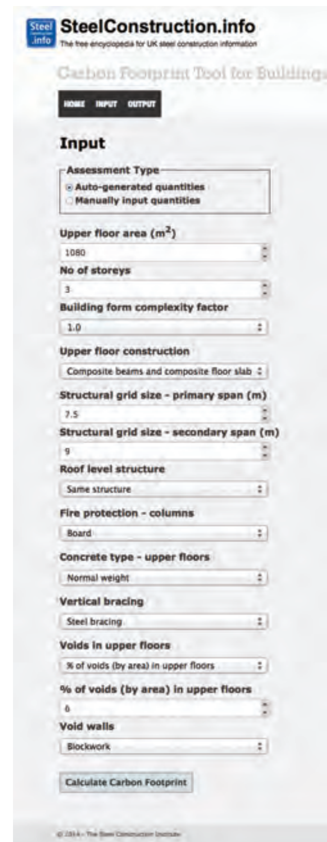
In order to assist designers, robust data has been sourced for the extraction and manufacture lifecycle stages and combined with an end of life dataset developed by PE International, a leading provider of sustainable solutions. The result is a robust and comprehensive dataset of embodied carbon impacts for materials commonly used in construction.

Data for all the materials can be viewed along with sources for the cradle to gate data used.

Designers using this dataset can have confidence in its transparency, robustness and consistency, enabling comparison between different frame options to be accurately and effectively carried out on any project.

BS EN 15804

BS EN 15804 provides rules to assist with the consistent calculation of embodied carbon, and divides the lifetime of a construction product into modules: A, B, C & D, some of which are further sub-divided. So for example, Modules A1-A3 cover the production stage (cradle to gate) and Modules A4-A5 cover the construction stage. For most construction products, A4-A5 are relatively small and are often ignored. The B modules cover the operational stage of the life cycle, but these are also generally small and are ignored. Modules C1-C4 cover the demolition, separation and removal process, and Module D takes account of the positive or negative impacts of recycling, reuse, or disposal to landfill. Adding these together as shown gives a cradle to cradle total.



Whole life embodied carbon data for common framing materials

Product	BS EN 15804 Modules			Total
	A1-A3 ($kgCO_2e/kg$)	C1-C4 ($kgCO_2e/kg$)	D ($kgCO_2e/kg$)	($kgCO_2e/kg$)
Brickwork	0.16	0.01	-0.0207	0.15
Concrete blockwork	0.09	0.0103	-0.0053	0.10
C40 concrete	0.13	0.0043	-0.0053	0.13
C50 concrete	0.17	0.0037	-0.0053	0.17
Lightweight C40 concrete	0.17	0.0111	-0.0053	0.18
Hollowcore slab	0.2	0.0006	-0.0103	0.19
Hot rolled plate and structural sections [1]	1.735	0.06	-0.959	0.84
Hot formed structural hollow sections [1]	2.49	0.06	-1.38	1.17
Reinforcing steel [1]	1.27	0.061	-0.426	0.91
Steel deck	2.52	0.06	-1.45	1.13

[1] Fabrication (bending, cutting and welding for rebar) impacts have not been included.

Cheesegrater's steel me

The iconic Leadenhall Building's structure in the City of London is an essay in the aesthetics of functionality and large-scale prefabrication

PROJECT REPORT
RUBY KITCHING

Project	Leadenhall Building, London
Main client	British Land and Oxford Properties
Architect	Rogers Stirk Harbour + Partners
Main contractor	Laing O'Rourke
Structural engineer	Arup
Steelwork contractor	Severfield

With the 46-storey Leadenhall Building now structurally complete, visitors to London's Square Mile can finally see how this new hi-tech skyscraper fits into the area. From certain angles, of course it looks enormous, as indeed it is at 224m tall. But the wedge-shaped building – also known as the "Cheesegrater"– is also good at concealing itself due to the way it diminishes with height.

The tapering design was dictated by the need to preserve sightlines across London and allows the building to effortlessly sink into the London skyline, without being too dominant. Closer to the ground, the building spreads across the entire footprint of the site, but its clever design has also allowed the ground floor area to be opened up as a public space and thoroughfare.


Exposed steel megaframe and chevron bracing in the main building and painted yellow steelwork in the north core define the architecture and engineering of the Leadenhall Building

16-20t
Megaframe nodes

Most tall buildings rely on a central concrete core to provide lateral stability for the structure. Leadenhall's clever design means that the massive steel perimeter structure – the "megaframe" - does this job, allowing floors to be more open and divided up more flexibly.

A central core would also usually house lifts, toilets and services risers, but these have been located in a separate "north core" block, identified by its striking painted yellow steel components. The north core is linked to the main building via a connecting section of floor plate at every level. Only two firefighting lift cores are present in the main building floors.

The "megaframe" (see box) is a seven storey module made up of six members coming together at a node point which sits between an outer single skin of glazing and an inner double glazed layer. Louvres every seventh storey allow air to circulate within the cavity to help keep the building cool in the summer. The building is set to achieve BREEAM 'Excellent' environmental rating.

"The megaframe, being on a very large scale (28m between nodes) had unusual buckling characteristics and the chevron bracing, which is expressed in front of the fire-fighting lifts, is an important part of the overall [stability] system and is required to stiffen the building horizontally between the node levels and keep the main megaframe members relatively slender," says Arup associate director Damian Eley.

Leadenhall is an office building from level four up. Lower floors are served by six escalators rising from the public ground floor area and accommodate two reception levels and a restaurant. Office floors step back 750mm from the one below to create the building's tapering form.

The internal office floor structure comprises composite steel floors consisting of 150mm deep concrete slabs over 700mm deep fabricated beams on a 10.5m by 16m grid. Only a maximum of six internal columns support each floor.

"Some of the plate thicknesses fell outside the remit of existing codes"
ALEX HARPER, SEVERFIELD

gaframe

Some nodes took up to 600 man-hours to fabricate at Severfield's factory

Construction on site began in September 2011. "The scale of this project is big," says Severfield project director Alex Harper. "It's what makes this project different – that and the tight [construction] timescale and tight site constraints," he adds.

The biggest challenge for Severfield was to deliver and connect the colossal 60t (maximum) megaframe components: "Big pieces of heavy engineering; big, thick components some of which had to be welded on site", recalls Mr Harper. As well as size, there were large quantities of beams to fabricate and erect on the office floors and a series of intricately detailed "table" structures for the north core (see box).

The longest members are the 24m long diagonal megafame members, which had to be delivered to the site between 1am and 5am and with a police escort. Cranes had to be specifically built for this project to lift such heavy components.

The aim of the game for Severfield was to reduce the number of splices to reduce the number of connections on site and save time. But without a central core to provide stability, there was no source of lateral stability during steelwork erection. So while steel structures arrived in prefabricated units for speed of erection, Severfield also had to spend time building a temporary steel braced core up to 14 storeys tall (at its maximum) to provide restraint while the megaframe modules were being built. The temporary core was dismantled and reused several times further up the building as each seven-storey megaframe was completed.

Tolerances were just +/- 45mm on the megaframe and +/- 25mm on the north core structures and relied heavily on highly accurate fabrication, which was made possible by Severfield's in-house, computer-controlled fabrication technique.

"Some of the plate thicknesses - 190mm thick in front elevation nodes – also fell outside the remit of existing codes, so we had to agree with Arup a procedure for sampling and testing welds," recalls Mr Harper.

What makes this building stand out, apart from its scale, is also the level of detail which has gone into the design and manufacture of each component. "I love the aesthetic part of the design process and [hope] that people can appreciate that there is a craft in making it look right, which is to say both tidy and that you can see how it is working," says Arup associate director Damian Eley.

MEGAFRAME

Typically, six elements come together at each node joint in a variety of angles within the megaframe, transferring forces of up to 6,000t in at least three different directions.

The nodes, weighing 16-20t, typically measuring 6m x 3m, connect straight megaframe members via pre-stressed bolted connections. The nodes provide the geometrically complex transitions between the different elements through welded joints between carefully orientated plates.

Stability for the mega frame presented another structural challenge since the seven storey megaframe modules are so big, the columns require a secondary stability system. This has taken the form of chevron or K-bracing panels, located in the northernmost bays of the east and west faces, the end bays of the north faces and around the smaller fire-fighting cores which are positioned in the office zones.

NORTH CORE

The north core block is made up of table-shaped modules for speed of construction. Laing O'Rourke pushed the boundaries of prefabrication on this project and here, services and the pre-cast floors were pre-installed on the steelwork before the tables arrived on site. Column splices for each table are also carefully concealed within the floor build-up and sandwiched between cladding panels.

"The north core secondary structure was designed to be minimal. Mostly hanging in seven-storey modules, it achieves great transparency around the lifts through the use of flat tension elements integrated into the cladding design. The connections involve various architectural elements such as pins and couplers and are very carefully co-ordinated to achieve a neat end-result that is consistent through all parts of this structure. This structure has to provide a very stiff horizontal restraint to the high-speed lifts, while at the same time managing complex differential vertical movements due to gravity and tension effects," says Arup associate director Damian Eley.

Hospital wing cured by s

A central London hospital building, which has suffered water ingress and excessive solar gain since it was first built in 1966, is being cured by a £27 million over-cladding programme

PROJECT REPORT
RUBY KITCHING

Project St Thomas' Hospital East Wing project, London
Main client Guy's and St Thomas' NHS Foundation Trust
Architect Hopkins Architects
Main contractor ISG
Structural engineer Arup
Steelwork contractor Bourne Steel

Constructed from reinforced concrete and clad in slate tiles with teak and stainless-steel framed windows, the 13-storey east wing building at St Thomas' hospital has always suffered from rain penetration. It has also suffered from being uncomfortably hot in the summer and being expensive to heat in the winter.

No doubt it looked fantastic back in the 1960s when it was first built, but the years have taken their toll on the exterior to the point where Guy's and St Thomas' NHS Foundation Trust needed to fix the building's problems, before things took a turn for the worse.

Closing the building while repairs took place was not conceivable as the east wing is a vital part of the services the hospital provides: containing 200 beds together with cardiology services, two intensive care units, and clinical suites, teaching facilities and ancillary plant and stores. With the normal running of the wing the priority for the Trust, work to cure the building's ailments had to demonstrate minimal disruption.

In 2010, the Trust embarked on finding a contractor-led project team which would meet its needs via a RIBA (Royal Institute of British Architects) competition. Main contractor ISG with structural engineer Arup and architect Hopkins were the winning team.

"We had a vision of putting a glass box over the top of the building to make it water-tight and also to allow it to perform better thermally," says ISG senior project manager Fraser Tanner. Other contractors wanted replace the glazing which would have required closing sections of the building at any one time. The ISG-Hopkins solution to over-clad the building


A new façade and two atria is giving the east wing building a new lease of life

using a suspended façade and two triangular atria would allow the hospital to function as normal while keeping the high quality (although not watertight) exterior unchanged. In fact, the scheme has also facilitated the original slate, teak, stainless steel and glazing exterior to be cleaned and repaired.

203x102
Typical lift core beam sections

Located on the south side of the Thames and opposite the Houses of Parliament, the east wing tower comprises two blocks arranged in a "T" shape. The western elevation or the shorter of the two rectangular blocks fronts the River Thames. Here, the cladding solution was to suspend a 30m wide, full height glass façade from the roof to avoid loading the ground and basement below.

This new façade is 1m proud of the original building line and allows a maintenance walkway to be fitted between the old and new cladding lines.

A new diagonal boundary line was struck across the corners of the T-shaped block to create two triangular atria. The northern most atrium has also been designed to accommodate a steel-framed lift core for two new lifts, a requirement from the Trust's brief.

The new cladding scheme incorporates more thermally efficient glazing and a ventilation system which will solve all the tower's water penetration and heating and cooling problems, and provide it with a new, fresher identity.

A single tower crane tucked between the east wing and its neighbouring building carries out


The original slate cladding allowed water ingress

teel

VALUE ENGINEERING

The degree of value engineering on this project has been extensive in order to keep the steel weight down where it is either supported off the existing building or by the few new foundations which could be constructed. Steelwork sizes and plate thicknesses vary across the entire new structure to ensure this eye-catching and sensitive design is both structurally and economically viable. The roofing material for the atria is ETFE which allows light into the new courtyards, but weighs much less than glass.

all lifting work (an option to mount cranes off the roof was abandoned due to the heavy loads it would exert on the existing building).

Steelwork contractor Bourne Steel is responsible for the new lift core, the atria's second floor podium structure and steelwork over the western block roof (see box).

The first structure to be erected was the new steel-framed lift core in the north atrium and the landing structures connecting it back to the main building. Lift core beams are typically 203 x 102 sections while columns sections vary with height from 152mm sections at the top to 203 mm sections near the bottom (see value engineering box). Connecting this structure back to the existing building required meticulous planning to avoid clashes with services and reinforcement in the original walls.

"Building the lift shafts within a confined space was a challenge," says explains Bourne Steel divisional director Kevin Clarke. "Each of the two lift shafts were constructed in two-storey modules which could be crane-lifted from the access road, over the building and into position [in the north atrium]," he explains.

On the rear elevation, a second floor podium had to be constructed over various ground level plant stores to create the base level for each atrium. The podium is made up of 600mm by 400mm fabricated box sections of varying thickness and a precast concrete floor made up of 4.2 x 1.5m panels.

"We even had 5m cantilevers here to avoid some of the plant," recalls Arup senior engineer Christian Dercks.

Supporting the atrium glazing in each courtyard is a single 200mm square box section column and a Y-shaped steel structure made from 350mm square box sections. Both are 12m tall and span from ground floor to the underside of the second floor podium. They sit on new foundations.

"We couldn't transport the whole "Y" to site due to its size, so fabricated it in three sections," recalls Mr Clarke.

Lateral trusses spanning 30m across the corners of the T-shaped building at alternate levels provide wind bracing for each atrium. Split into three, 10m long sections for transportation, the sections were welded together on site, lifted into position and bolted back to existing concrete. Diagonal cables also form part of the stability structure for the atria glazing.

A mighty 40km of scaffold tube have gone into constructing the temporary structure from which the two atria roof steelwork have been erected. The roof steelwork is made up of 219mm diameter tube sections and were built in four chunks to aid speedy and safe erection.

The north atrium and western elevation façade are complete and work is now focussed on completing the south atrium. Completion is due at the end of this year.

"We even had 5m cantilevers here to avoid some of the plant"

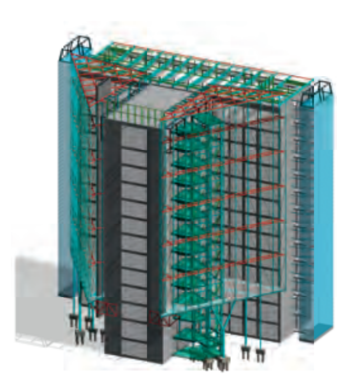
CHRISTIAN DERCKS, ARUP

40km
scaffold tube used

The western elevation façade is suspended from new roof steelwork

WESTERN ELEVATION CLADDING SYSTEM

A new steel frame comprising 13.7 m long, 450mm by 250mm box-section beams across the depth of the western elevation block had to be built at roof level to support the new western elevation facade. Built by Bourne, this new roof structure has also added an extra useable floor for the Trust, where previously there was just a plant enclosure.



Steel structure showing the steel lift core in the north atrium

Glasgow mall branches o

Extending the Silverburn shopping centre on the outskirts of Glasgow has required careful planning to ensure minimal disruption to shoppers and businesses

PROJECT REPORT
RUBY KITCHING

To compete with their city-centre rivals, the business model for out-of-town shopping centres requires them to offer more than just a great shopping experience. Retail developments on the outskirts of cities are considered destinations where visitors not only go to shop, but also expect to dine in stylish restaurants and, later, take in some evening entertainment.

The Silverburn shopping centre, located in Pollok, south west of the city of Glasgow, ticks all the boxes for its wide range of retail offerings, but currently lacks the dining and leisure facilities to match. Developed in phases since 2006 (see box), Silverburn is steadily replacing the former Pollok Centre with a more modern retail experience. Phase three, the last to be redeveloped, is currently nearing completion. This 10,900m² extension to phase two will house a 14-screen Cineworld cinema, Gala Bingo hall and nine restaurants including Carluccio's, Cosmo and Pizza Express.

Project Silverburn shopping centre, phase 3, Glasgow
Main client Hammerson
Architect BDP
Structural engineer Cundall
Design and build contractor Graham Construction
Steelwork contractor Walter Watson

PHASE 1 AND 2

Steel framed construction has allowed the Silverburn redevelopment to take place in a speedy and flexible way. Steelwork contractor Severfield erected more than 7,300 of steel for Phase One of Silverburn, which opened in 2007. Phase 2 of the project required 3500 tonnes of steel and extended the phase one area by a further 150m. Phase two included a large, glass-covered Winter Garden.

The £20 million steel-framed development comprises retail units and a bingo hall on the ground floor, cinema and associated facilities on the first floor and projection and lounge facilities at second floor. All connections were designed to be bolted on site as welding posed a fire risk to the shopping centre.

The main contractor is Graham Construction, structural engineer is Cundall and steelwork contractor is Walter Watson.

The structure is a beam and column-type frame with bracing concealed within the floor and walls. The floor slab at ground floor is concrete, composite for the first floor and precast concrete for mezzanine levels. Extra steelwork was required to form the external elevations of the building which are angular cladding panels.

The structural scheme also had to be designed to stringent acoustic criteria to ensure a high quality sound experience for movie-goers, which did not disturb other parts of the complex. (see box)

The tower was connected up at ground level before being lifted whole onto the roof

"The frame itself weighed 10 tonnes and had to support a 25m column"

TREVOR IRVINE, WALTER WATSON

With 14 million visitors a year, Silverburn's 1800 tonne steel-framed extension had to be built without disruption to shoppers or retailers.

One of the main challenges for the project team was to access the site which is bound by a river (burn) to the west, a Tesco store to the east, dual carriageway to the north and existing shopping centre to the south. Also the shopping centre had to keep a safe means of pedestrian access throughout the build via a covered walkway from the north-west corner of the site to the existing shopping centre at the south. (see walkway box)

With the walkway bisecting the site, construction had to take place one half at a time, starting with the southern end first. Site demolition began in 2013 on the southern half of the site first. Steelwork erection on the south side of the walkway commenced when demolition of the northern half of the site was still in progress.

"We used 3D BIM to optimise the construction sequence and understand the impact of our works on all interfaces with the existing facilities," says Graham Construction regional director Gary Holmes.

"Being very close to the Brock Burn, which is within an area of Importance for Nature Conservation, great care had to be taken to ensure that the construction process did not

ut

The site was bound by the existing retail units, a road and river, making access challenging

affect this natural habitat," he continues.

Graham Construction has also remodelled a section of the internal winter gardens within the existing mall, created a new taxi rank, extended the bus station canopy and installed new paving between the new extension and the neighbouring Pollok Civic and Realm.

Working around the normal running of the shopping centre and within a constrained site, has meant that the full height of the building had to be built as construction progressed on each half of the site. This required installation of metal decking, precast slabs and precast stairs to be concurrent with the main steelwork erection. An 8m tall, approximately 3.5m square architectural tower on the roof had to be lifted into position in one piece made up of 150mm diameter sections.

Large installations had to be carefully programmed to take place over night.

"The new escalators also had to be brought to site in the early hours of the morning so that they could be craned over the burn and into the building to their final position," comments Mr Holmes. The escalator installation took two nights to complete.

Close liaison between Graham Construction and the centre owner and retailers has meant that the construction programme has been ahead of schedule in some areas, so retail units have been handed over early for fit out. Phase three will be completed in Spring 2015.

THEATRE STEELWORK AND ACOUSTIC DESIGN

Because of the acoustic requirements of modern cinemas, column splices were not permitted within the 26m height of each theatre. This created the challenge of having to lift long sections of steel using a 50t mobile crane into the confined site and required very careful coordination, often maximising the reach of MEWPS to complete the task. Auditoria roofs are supported by 1500mm deep trusses spanning 23.6m (brought to site in two sections). Raking beams and a steelwork frame support in situ concrete terraces for the seating. Steelwork for each theatre had to be acoustically isolated from the main frame and required rubber endplates and washers designed to specific structural and acoustic loads to be included in connection design.

WALKWAY

Keeping public access across the construction site meant that no steelwork could be erected over the walkway during the Centre's operational hours. Instead steelwork which passed over the walkway had to be constructed between midnight and 5am. The column and foundation layout required one column at ground floor and rising up 30m through the full height of the building to be located within this public walkway zone. "We had to design a temporary frame [which straddled] over the walkway and allowed the column to sit on the frame from first floor level up to roof," explains Walter Watson structural division general manager Trevor Irvine. "The frame itself weighed 10 tonnes and had to support a 25m column," he adds. When all the full height construction work in this area had been completed and the walkway removed, the 5m long permanent column from ground to the underside of the first floor could then be erected and the temporary frame removed. The process required jacking up the 25m long column a few millimetres to allow the 5m column to be inserted underneath and connected up, then jacking it down to its final position before making further connections.